

Energy Independence Through CDM Using Geothermal Resources: Indian Scenario

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ABSTRACT

With increasing population growth, demand for clean power will increase world over. This demand will be more in developing countries. CO₂ emission by Non-OECD countries will exceed the OECD countries by 2010 and will reach 10000 million tons by the year 2030. Financial incentive is a great motivation for developing countries like India to surge ahead with CDM. In fact, developed countries can pay developing countries to reduce CO₂ emissions by obtaining "credit" on their own emission targets. This carbon credits initially may help the Non-OECD countries but prolonged dependence on such credits is not good practice to these countries. One advantage is that the developing countries will benefit by a technology transfer from developed countries, thereby attracting foreign investment. Harnessing geothermal energy source that has low carbon emissions is a viable option for Non-OECD countries. Both low enthalpy geothermal resources as well as enhanced geothermal systems (EGS) have greater role to play in countries like India that has abundant low enthalpy as well as EGS sources. India, being a part of Non-OECD, will face socio-economic set back if CO₂ emission is not controlled and depend too much on carbon credit. The current per capita GDP for India is around 1000 US\$ per person and the per capita energy consumption is 631 KWhr, which is far below the Asian countries. India's ambition to increase per capita energy consumption to 1000 KWhr will only increase further CO₂ emission due to burning additional 263 million tons of coal. This amounts to emission of 870 million tons of CO₂. The current production of electricity from coal alone is about 75002 MWe which is equivalent to 4×10^{12} carbon equivalents in tons (CET). India can very well adopt CDM by utilizing its available low enthalpy and EGS geothermal resources considering the volume of high heat producing granites available in the country. Roughly, the granites occupy an area of 150,000 sq. km (surface area) with a major volume of these granites having heat generating capacity of the order of 3 to 5 $\mu\text{W}/\text{m}^3$. For example, estimates on a small volume of granite from northern part of India indicate that it has the potential to generate a minimum of 61160×10^{12} kWh. Similar potential of granites from other parts of India have also been estimated. If India's CDM initiative could reduce carbon emission by about 5 %, then the minimum revenue it can generate is about 160×10^{10} euros. In future such revenue generated through EGS could make India's energy independent and fulfill the country's ambition of increasing the GDP at least by a factor of ten relative to the current value, thereby increasing the socio-economic status of the country.

1. INTRODUCTION

Energy independence and greenhouse gas (GHG) emission from fossil fuel based power plants are a great concern for both the developed and developing countries today. The demand for electricity over the world is projected to rise from the current 16,424 TWhr to 30,364 TWhr in 2030 (Chandrasekharam and Bundschuh, 2008). In developing countries (non-OECD countries: Organization for Economic Cooperation and Development) this demand is expected to grow at the rate of 3.5% compared to 1.3% in Organization for Economic Cooperation and Development (OECD) countries. The reason for electricity demand in the non OECD countries is due to highest population and economic growth while in the OECD countries this demand will be only due to economic growth (Fig.1). Therefore it is important for the non-OECD countries to be judicious in planning for future energy needs and avoid socio economic issues arising out of environmental problems. Per capita primary energy consumption, per capita GDP and per capita CO₂ emissions, are interlinked and are lower in the non-OECD countries. India and China will compete with each other to climb the GDP ladder in spite of a step growth in population (Fig. 1).

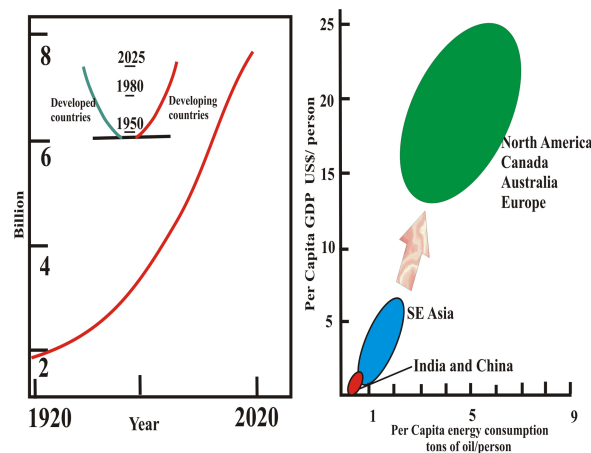


Figure 1. Population and GDP growth trends of non OECD and OECD countries.

Among the non-OECD countries, India and China will compete with each other to achieve higher GDP and hence per capita electricity consumption in spite of their growing population. As long as population is considered as a resource, capable of contributing to the economic growth of the country, its growth will have positive impact rather than negative on the country's development. India as on today is generating 141,080 MWe and is expected to double this generation capacity by 2015000 MWe, by burning 263

million tons of coal thus generating 870 million tons of CO₂. Coal remains India's most important fuel, its use nearly tripling between 2005 and 2030. Much of India's coal needs in future will have to be met by imports. India will continue to rely on imported coal for reasons of quality (high ash content) and for economic reasons (IEA, 2007). By 2030 hard coal imports by India is projected to increase by seven fold. (UNEP, 2008, IEA, 2007). As described in this volume, India has sufficiently large wet geothermal systems as well as a huge EGS spread all over the country. Considering its geographical extension, India can very well implement Clean Development Mechanism (CDM) by using low enthalpy as well as EGS geothermal resources as a primary energy source mix and become a carbon free country in the next two decades and can trade carbon in the world market. India is in an advantageous position as far as its geothermal resource potential is concern. China is able to exploit hot water available in the wide spread sedimentary aquifers for space cooling and heating, thereby saving electricity consumption from primary fuel and controlling CO₂ emission even though it tops the list of highest CO₂ emitter in the non OECD countries (IEA, 2007).

2. POWER SCENARIO IN INDIA

As shown in the table 1, 64.4% of electricity is generated from coal thermal power plants while a meager 7.7% is generated by renewable sources that include wind, solar, biomass and biogases. Geothermal does not figure in the renewable although > 265 MWt of energy from the thermal waters is being utilized at present. Independent power producers generate only 10760 MWe. Thus a major percent of power is generated by public sector companies. India is planning to increase the power production by 78577 MWe by 2012 to increase per capita electricity consumption from 631 kWhr to 1000 kWhr. With respect to the electricity growth rate in non-OECD countries (Figure 2), India's growth rate of <4% (though the MOP annual report indicated 6.3% growth rate, MOP 2008), India can not achieve anticipated per-capita consumption by merely burning an additional 263 million tons of coal. This will only drift the country away from implementing CDM unlike other European countries. In fact its future economic competitor, China, is reducing CO₂ emissions by utilizing its low enthalpy energy geothermal energy resources for space heating and cooling (Jiurong and Jianping 2005)

Table 1: Power generating scenario from various sources.

Plant/Fuel type	MWe		Percent
Thermal	90895		64.4
Coal	75002		53.1
Gas	14691		10.4
Oil	1201		0.9
Hydro	35209		24.9
Nuclear	4120		2.9
Renewable	10855		7.6
Total	141080		

India has to rely on coal and oil imports in future to sustain its socio-economic growth. By the year 2030, India's

dependency on coal will grow thrice the present use and it is heavily going to depend on imported coal and oil. By the year 2025 India will overtake Japan in oil imports with the demand growing to 6 mb/ in 2030 (IEA, 2007). According to estimates, India needs to invest US\$ 1.25 trillion (2006 base value) in energy infrastructure and three quarters in power sector. India's gross power generation capacity additions in 2030 will exceed 400 GWe which is equal to the current combined capacity of Japan, Korea and Australia (IEA, 2007). This is going to make India the world's third largest emitter of CO₂ by 2015 (IEA, 2007). However, there is a hope for the country to reduce emission volume if larger share of less carbon intensive energy sources are used as primary energy mix. This will yield a saving of 27% in CO₂ emissions by 2030 by reducing the emissions by 0.9 Gt.

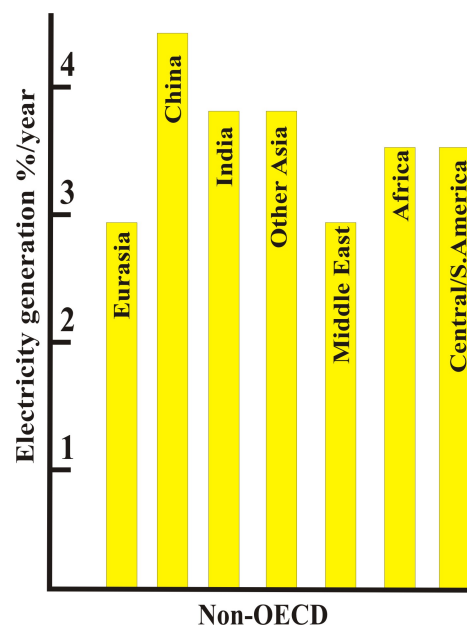


Figure 2. Electricity growth rate in non OECD countries.

3. GEOTHERMAL RESOURCES IN INDIA

The geothermal energy of the Earth is unlimited. Only a part of the geothermal energy stored in the crust to a depth of about 3-4 km is estimated to be 43×10^6 EJ corresponding to about 1194×10^6 TWh (Björnsson et al. 1998). Even the small part (<1%), that corresponds to the currently available share and can be extracted economically using the existing technology is vast compared to the total world net electricity generation, which is expected to grow from 16,424 TWh in 2004 by 85% to reach 30,364 TWh in the year 2030 (EIA 2007). Thus geothermal resources are much larger compared to all fossil fuel resources put together whose energy and electricity equivalents are 36,373 EJ and 1,000,400 TWh, respectively, corresponding to 1317.4 billion barrels of oil (corresponding to 8062 EJ or 223,900 TWh); 6183 trillion cubic feet of natural gas (corresponding to 6678 EJ or 185,500 TWh), and 998 billion short tons of coal (corresponding to 21,634 EJ or 600,900 TWh) (EIA 2007). If we consider that actually only a small part of the geothermal energy resources can be tapped, for example, from either low enthalpy wet geothermal systems (WGS), that is available around high enthalpy systems, or enhanced geothermal systems (EGS) applying artificial fracturing of the geothermal reservoir, or using advanced heat exchanger technologies, which reduce the minimum fluid temperature required for power generation, the world's geothermal

resource will remain available for future generations long after the last drop of oil is produced. Continuous development of innovative drilling, power generation technologies and efficient heat exchangers makes this source the best future option available to meet the growth energy demand in the world. According to the MIT report on geothermal energy (MIT report 2006), geothermal energy is going to be the future energy sources for the developed and the developing world and can sustain for centuries without causing damage to the environment.

Nearly 400 low to medium enthalpy thermal springs are distributed in seven geothermal provinces in India (Fig. 3). The surface temperatures of these springs vary from 47 to 98°C. Extensive geological, geophysical and geochemical investigation on the thermal waters and thermal gases have been carried out (Chandrasekharam, 2000, 2005 and the references therein). Besides the low enthalpy geothermal resources, India has a large EGS potential that is waiting to be exploited (Chandrasekharam and Chandrasekhar, 2008a, 2010, Chandrasekhar and Chandrasekharam, 2007, 2008, 2009). These geothermal sites are pilgrimage centres (Chandrasekharam, 2007) and the thermal waters are directly being used for balneology and for cooking (Chandrasekharam, 2007b, GRC 27).

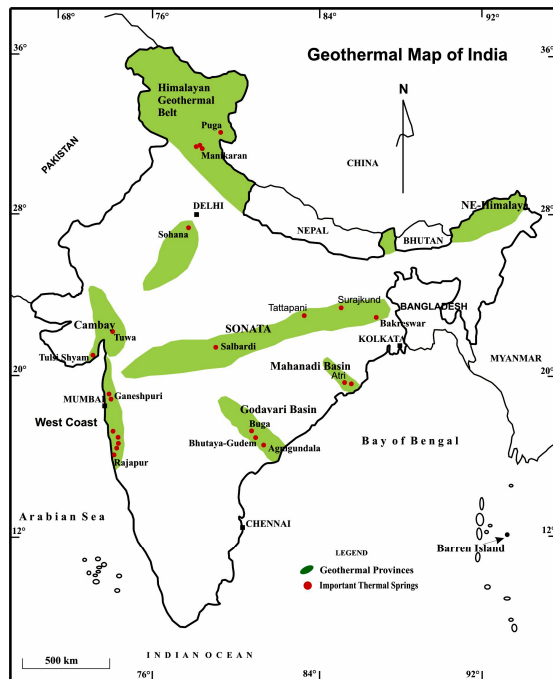


Figure 3. Geothermal provinces of India.

Estimates on 50 thermal springs located around important pilgrimage centres show direct utilization of 265 MWt energy (Chandrasekharam and Chandrasekhar, 2010). In fact, all the 400 thermal springs are accessible for utilization and if exploited they will provide > 10 fold the current utilization. The distribution of the thermal springs in different geographic and temperature zones is advantageous for direct utilization purpose like space heating and cooling, dehydration and green house cultivation. With the advanced drilling technology and efficient heat exchangers, geothermal resources in India, besides generating power, can contribute significantly in mitigating GHG emissions and mitigate global warming and become CDM forerunner in the world. In addition to the existing low enthalpy wet geothermal systems, the country has huge EGS resources spread across all its states extending from the Himalayas to the southern part of the country. Its EGS strength is drawn

from high heat generating granites occupying a surface area of 15000 sq. km. For example, EGS reserve estimate made on a small granite exposed area of 1000 km² in Ladakh in the Himalayan Geothermal Belt is about 61160×10^{12} kWhr. Similar EGS reserve in Madhya Pradesh and Andhra Pradesh (1000 km² granite) is 24464×10^{12} and 111200×10^{12} kWhr (Chandrasekharam and Chandrasekhar, 2008a, 2010).

4. CDM THROUGH GEOTHERMAL ENERGY SOURCE MIX

Compared to all the countries, OECD Europe is expected to increase renewable energy share in its power source mix from the current 19 to 23%. Europe is already at the top of low emission countries list and currently trading carbon at the rate of ~ 8-10 euro under certified emission rate (CER). India is a major customer (China tops the list) for carbon trade with Europe and continue to be so for the next decade, considering the future power demand and generation of power from coal based thermal power plants. By the 2030 India will be fully under the control of Europe with huge piled up credit. Both wind and geothermal are playing a major role in primary source mix in Europe's power scenario (AWEA, 2007). But this situation can be overcome if India utilizes its geothermal energy sources.

The Kyoto Protocol which entered into force on 16th Feb 2005 aimed at developed countries for emission targets and is open to developing countries through Clean Development Mechanism (CDM). This was an opportunity for the developed countries to transfer technology to reduce emissions and also to invest in developing countries to promote CDM. In fact it is an opportunity for the developing countries to quickly adopt carbon free technology to generate power and get value for their own carbon emissions under certified emission rate (CER). The quality of environment is closely related to the fossil fuels, especially coal. In many developing countries, like India, poor environmental quality does not affect the economic performance of the industries directly but may force substantial costs to the society in terms of poor health, damage to the vegetation and the buildings. This kind of situation exists because the major pollutants are the large industries that play a major role in development growth of the country. Geothermal energy resource can provide a stable supply of energy, in contrast to many alternative domestic renewable energy resources like hydro, wind and solar photo voltaic in all the developing countries like India. If such sources are not utilized to the fullest extent, then the carbon emissions in the non-OECD countries will only see an upward trend unlike the OECD countries (Figure 4). Details of emissions of individual OECD and non OECD countries can be obtained from Chandrasekharam and Bundschuh (2008, Table 4.1).

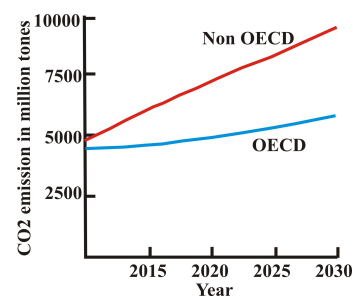


Figure 4. CO₂ emission rates in non-OECD and OECD countries (modified after Chandrasekharam and Bundschuh, 2008).

On an average, geothermal power plants emit 0.893 kg CO₂/MWhr while coal power plants emit 953 kg CO₂/MWhr (UNFCCC, 1997). The combined (wet low enthalpy and EGS) geothermal potential of India, taking into account the 150000 sq. km high heat producing granites, spread over the continent extending from the HGB to the southern part of the continent, on a conservative side amounts to 18348 10¹⁴ kWhr (Chandrasekharam and Chandrasekhar, 2008a). At a growth rate of ~ 4% (see section 2 and figure 2), by 2030 coal alone will add about 414 x 10⁶ MWhr. By utilizing the geothermal energy source, India can save about 396 x 10⁹ kg of CO₂. At the current CER rate of ~ 10 euros/tCO₂, this amounts to 396 x 10⁷ euros. This amount is more or less equal to the US\$ 1.25 trillion estimated (see section 2) for energy infrastructure development. Further, 33% (245 x 10⁶ MWhr, only coal power) of electricity in India is utilized by the building sector (commercial and domestic). A major amount is spent for space cooling, refrigeration and hot water supply. This amounts to emission of 234 x 10⁹ kg CO₂. If India utilizes low enthalpy geothermal sources (through Ground source Heat pumps: GHPs) and save additional revenue of 234 x 10⁷ euros under CER.

In fact CDM can be implemented immediately in Leh Ladakh in J&K State using geothermal energy and earn substantial savings through CER. Leh, gets its electricity from 6 diesel generators that generate 8 MWe (49056 MWhr) burning 3 million liters of diesel and emitting about 41 x 10⁶ kg CO₂. (@ 817 kg CO₂/MWhr, for oil, UNFCCC, 1997) (Chandrasekharam and Chandrasekhar 2008b). Incidentally Leh is located within the HGB (Puga and Chumathang geothermal fields, Figure 1) which has potential of generating > 250 MWe (about 2 x 10⁹ kWhr) from wet geothermal sources (Chandrasekharam, 2005, Chandrasekharam and Chandrasekhar, 2008). In addition to this, the EGS potential of the high heat generating granites of HGB, on a conservative account is about 1501 x 10¹⁵ kWhr (Chandrasekhar and Chandrasekharam, 2008). By implementing CDM through geothermal energy sources, besides providing projected electricity demand to Leh (54 MWe) in the next decade, the region can save the currently retreating Gangotri glacier (retreating at the rate of 18 m per year, Chandrasekharam and Chandrasekhar, 2008b) and preserve the pristine Himalayan environment for the future generation (Chandrasekharam and Chandrasekhar (2008b). The retreating glaciers of the Himalayas could present the most far-reaching challenge to the region. The Himalayas are a vital life-sustaining resource for South Asia. Any damage to the pristine Himalayan ecosystem will influence the monsoon dynamics of SE ASIA there by posing unprecedented threat to water supply, flood risks, sea level rise and damage to coastal ecosystem and causing severe damage to the agricultural ecosystem (IEA, 2007).

Further, in Leh, due to its geographical location and climatic condition (temperature in winter is around -35°C), diesel is being used for space heating during winter months (Sept-Feb) creating an additional CO₂ emission. This region is suited for creating space heating facility on a regional scale using the widely spread geothermal resources. In fact the HGB has the potential to generate surplus electricity through geothermal resources and make J&K and neighboring states zero electricity deficit.

Considering the carbon credits a country can gain through CDM, this is a good instrument for India to develop its huge geothermal energy resources. Although India is branded as the most extensive coal user, emitting substantial amount of CO₂ (ranks second in the non OECD countries, IEA, 2007 and also see section 1), by implementing CDM through low

carbon geothermal energy resources, India can become the leader among the non OECD countries in piling up huge carbon credits, like Europe, and lead the other developing countries in south east Asia and Africa and central Americas. As shown above, only by implementing low carbon energy sources energy for future buildings in the urban sector, India can reduce hard coal from other countries and build high capital to support geothermal projects. CDM of the Kyoto Protocol has paved the way to alternative financing portfolio regarding energy efficiency improvement projects in this sector, in collaboration with the international financial players like Europe and Japan. These two countries are active in the global carbon market for the last several years. Europe completely dominated the CDM market in 2006 with 86% transaction volume with China dominating CDM market accounting for more than 70% global transaction volume. China's trade is mostly focused on non-CO₂ GHG reductions related to energy efficient projects (China ranks first in the non OECD countries, IEA, 2007). On a long term such efficiency project may not fully support CDM mechanism unless source energy with less carbon emissions, like geothermal dominates the market.

In addition to the building sector, implementing CDM in food processing sector also will provide additional benefit to the country in reducing CO₂ and earning carbon credits. India is one of the world's major food processing countries, accounting for 1.5% of international food trade. Foreign investment in food sector, after economic liberalization, stood at 2 billion US\$ in 2002 with an annual increase of 15% growth. Thus it is a good opportunity for India to attract foreign investment in this sector under CDM by promoting geothermal energy in sector (MFP, 2008; Chandrasekharam, 2001). India's total food market is estimated at US\$ 70 billion and value added products is estimated at US\$ 22 billion. If the situation is so attractive then why is India not able to cash on this opportunity? Lack of growth in this sector is due to poor infrastructure facilities like cold storage, dehydration and tax incentives. About 80% vegetables and fruits perish due to high water content. Due to lack of such facilities, food worth 2.5 billion US\$ is wasted annually with farm products share of 1.5 billion US\$. India can very well exploit its geothermal energy sources for food processing facility there by earning the required capital to build this state of art storage and processing facilities and become the top trader in the world food processing sector. By using conventional fuel, as it is the practice now, India can never compete with the world food processing market. For example, 250 gm of dehydrated onions costs 0.5 US\$ in the Indian market today while the price of 1 kg of raw onion from the procurer costs 0.1 US\$. It should learn a lesson from a small country like Guatemala in Central America that uses geothermal for food processing and captured the European market in dehydrated food (Chandrasekharam, 2001). This industry requires about 6 billion US\$ to strengthen infrastructure by creating state of art storage and production facilities. Indian food sector uses about 13 % of the electricity (IEA, 2007) amounting to 63 x 10⁶ MWhr (from coal fired thermal power plants). Thus part of the capital, amounting to 600 x 10⁶ euros can be raised through CDM and ploughed into this industry by using geothermal sources instead of conventional fuels.

5. CONCLUSIONS

Clean Development Mechanism under Kyoto Protocol is an excellent instrument for India to raise above all the non-OECD countries with respect to controlling carbon emissions, earning carbon credits, improving the environmental and GDP growth in the next two decade provided it exploits its geothermal potential to its maximum

capacity in all sectors like power, building and food processing. While China is exploiting its geothermal resources and plans to expand further in the HGB, India is still allowing its pristine Himalayan ecosystem to degrade, in spite of repeated scientific reports indicating the potential of geothermal resources in the NW Himalayan region. India can disprove IEA's (IEA, 2007) prediction as the world's third largest emitter of CO₂ by 2015 by using its wet and EGS. India's estimated wet geothermal potential (80 x 10⁹ kWh) and EGS potential (18348 x 10¹⁴ kWh) are far greater than the future projected electricity demand from coal based thermal power plants by 2030. As described, all the power plants are owned by public sector companies.

In order to exploit the potential gains of geothermal energy by increasing applications of geothermal resources for electricity generation, the countries must overcome barriers that obstruct the development of this energy source and create or improve policies on sustainable renewable energies. Geothermal energy should be integrated in the development plans, and decisions should not be taken exclusively from a purely market point of view. The national authorities will have to take advantage of the benefits of CDM and focus should be on two domestic targets: 1) Preparation of a plan for an extensive coordination of the national electricity markets and to develop regional wholesale electricity markets. This limits the negative impacts of uncertainties, both, with respect to the markets and to technological performance; 2) Internalize the social costs of the so-called negative externalities of energy production. One way to do this is to impose fine for the activities that contribute to air pollution (this is being implemented in several countries as "carbon tax). Then social advantage of "clean energy" thus becomes visible. But this easier said than done in countries like India where the polluters are often the large industries that play an important role in the economic growth of the country as well as holding control over major policy related to energy in the country. Political will and determination to induct modern technological innovation for the socio-economic growth of the country is very essential to make countries like India to be at the top of non-OECD countries.

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